THE WORK OF THE WEATHER BUREAU AND ITS RELATION TO ENGINEERING.

By J. WARREN SMITH, M. S. Read before Engineers' Club of St. Louis, April 20, 1910.

Engineers are oftentimes vitally interested in temperature and wind records. But as both temperature and wind conditions are fairly uniform over large areas it takes but a few points of observation to establish general and satisfactory values.

The temperature of a locality depends upon its latitude, altitude, and prevailing wind direction. Wind values are influenced by the general circulation of the atmosphere and the topography of the country.

For all practical purposes we may consider the same temperature and wind values in southern Ohio as in central Missouri, for example, and can calculate that the same wind and temperatures will have the same effect upon construction work or manufacturing or advance of vegetation in one place as the other.

This is not true of rain or snow, however, and especially of the movements of the water after it has been precipitated. The meteorologist may be wrapped up in his study of the movements of aqueous vapor in its grand meteorological cycle, precipitation, evaporation, condensation.

The climatologist may spend his time with the relation between the weather elements and the latitude and topographic features.

The engineer, on the other hand, wants to know where the water falls, how it falls (that is, the character of the precipitation and rate of fall), and above all where this water is going and how it is going to get there, and not only that but what is going to happen while it is on the road.

He may work out some very pretty theories based upon the topography, temperature, prevailing winds, etc., to answer these questions, but nothing in the world will answer them correctly, but the actual observations. And the problem must be worked out anew for each individual drainage area and parts of drainage areas.

The problems of the hydrological engineer especially, are problems of run-off, evaporation, precipitation.

Run-off.—Some valuable studies have been made of this complex subject, but each river basin is a problem in itself, and while we may establish some very general relations like Newell's 35 to 47 per cent of the rainfall (Water Supply and Irrigation Paper No. 80), the careful engineer will give each case very thorough investigation.

The Weather Bureau proposes to assist in the solution of the run-off question by publishing the daily river gage readings and stream-flow measurements in the MONTHLY WEATHER REVIEW, beginning with January, 1911.

To be sure, the river gage readings have been published by the Bureau for a good many years, and the stream flow figures have appeared in the Geological Survey annual reports, but in both cases the data have appeared many months after the observations have been taken. But now they will be placed before the engineers from month to month, and in the same volume with the figures showing precipitation of the drainage area.

Evaporation.—It is not necessary to tell a body of men like the St. Louis Engineer's Club that the importance of determining just what the real evaporation from water supply and irrigation reservoirs is can hardly be overestimated, especially in arid regions.

In some instances reservoirs built at large expense are nearly or quite dry during most of the year, because the builders did not know the evaporation values.

It has been estimated that the evaporation in southern Arizona is about 6 feet a year. If this is true the loss of water from evaporation from a reservoir like the Roosevelt reservoir, covering 16,320 acres, would be sufficient to irrigate 48,960 acres of land.

After the break in the Colorado River had been closed and it was known that the great body of fresh water in the Salton Sink, containing in May, 1907, 440 square miles of surface area, must be practically dried up in 10 to 12 years by evaporation, it was determined to take the opportunity to study evaporation in the arid regions on a large scale.

After a board of conference had visited the Salton Sea region, the work of investigation was placed in the care of the Weather Bureau, and Prof. Frank H. Bigelow was put in charge.

Professor Bigelow found that when the results from different evaporation formulas were brought together the constants did not agree. He thought it wise then to determine the cause for the discrepancy and to ascertain the correct formula if possible.

Consequently he established 5 towers 40 feet in height in and about the Reno, Nev., city water supply reservoir for the purpose of making a preliminary study. Evaporation pans were located at different elevations on these towers and pans were located at different points in the reservoir. Twenty-nine pans were distributed in this way and observations made every 3 hours.

From these observations Professor Bigelow determined that a vapor blanket always overlays any body of evaporating water, and largely controls the evaporation from water surfaces and irrigated fields.

At Reno this vapor blanket seemed to have a depth of 40 feet over the city reservoir, but it will vary with the size of the sheet of water and the climate in which it is located. He states that in dry climates it will overspread the water laterally from 300 feet to one-fourth mile, according to the size of the water area. In moist climates it will be deeper and more extensive.

In the arid regions of the West it seems probable that this vapor blanket conserves about three-eighths of the water that would otherwise be lost by evaporation, but this rule may not hold true in other climates.

It was determined that if the water evaporated between 7:30 a. m. and 10:30 a. m. at Reno in the summer time be multiplied by 8 the vaporation for the 24 hours of the day will be very closely determined.

Professor Bigelow worked out a very satisfactory formula from these observations and has now attacked the larger problem of the Salton Sea. Observations were opened in March, 1909, at 5 points about the Salton Sea, and simultaneously stations were established at 12 other points in the West and 5 east of the Mississippi River.

Hence it seems that it will not be long before the Bureau can place very valuable data and formulas in the hands of engineers for determining the evaporation from storage reservoirs and watersheds in any part of the country.

Precipitation.—A vast amount of rain and snowfall data have been accumulated during the past 25 or 50 years in this country. Much of the information is not available, to be sure, and yet my experience is that comparatively few engineers appreciate the large amount that is available or know where to look for it. Every few days engineers will come into our office, and, after seeing the precipitation figures that we can furnish them, say that they never dreamed that so much information could be had.

Meteorological observations began at a few places on the Atlantic coast in the 18th century and at a few points west of the Appalachian Mountains early in the 19th century. Army post surgeons were among the first systematic observers.

Later the Smithsonian Institution encouraged voluntary observations, and finally in 1871 the United States Government began its official meteorological records with its organization that has since developed into the splendid weather service that we have to-day.

There are now about 200 stations, at which nearly all the meteorological elements are being noted regularly by self-recording instruments. Among the most important of these from the engineer's point of view is the self-recording rain gage.

At a few stations in the northern part of the country the exact rain and snow fall is recorded to the one-thousandth part of an inch, as it falls. At most of the other stations the instruments record every one-hundredth of an inch of rainfall. The duration and intensity of fall of every summer thundershower that passes over the station is accurately shown as well as the rate of fall of the more moderate soaking spring rain.

In addition to the regular stations, which, of course, are widely scattered, there are now about 3,600 cooperative observers, who are equipped with reliable maximum and minimum thermometers and standard rain gages. There are 100 of these cooperative stations in the State of Ohio and nearly that number in Missouri. In California the daily precipitation observations are carefully made at no less than 307 different points.

The results of these observations have previously been published in monthly form, each State in a bulletin by itself. In order to get the rainfall for any station one would need to go through a great many reports. Recently, however, the precipitation data over the limited areas have been compiled and published in a series of separates. The United States has been divided into 106 districts and all the precipitation data in each district, together with the average temperature and wind conditions, published in a single report.

Besides the general discussion and climatological tables these reports contain valuable notes, furnished by the Geological Survey, concerning the water power of the district under consideration. Up to date not quite one-third of the publications have been issued, although all are in the process of preparation. Engineers wishing to know the precipitation over any part of the United States should write the Washington office of the Weather Bureau and ask for the latest publication covering the information. If the separate for that section is off the press it will be sent at once.

Heretofore these cooperative stations have been largely located in the fairly thickly-settled farming districts, and they have been very scattering in the more remote mountain regions. Yet the recent interest in the development of water power and supply reservoirs has brought a special demand for a knowledge of the amount of rain and snow available in the mountains and valleys near the headwaters of the large main streams. And since it is the snow accumulated in drifts in the mountain ravines or packed in forests which is the real source of the water supply used for irrigation, it became necessary to give special attention to the amount of snowfall in the high levels of the mountains of the West.

This was brought about through the cooperation of the United States Weather Bureau, United States Forest Service, and the United States Bureau of Plant Industry, of the Department of Agriculture, and the Reclamation Service and the Water Resources Branch of the Geological Survey, of the Interior Department. This inter-Bureau cooperation plan went into effect July 1, 1908.

The problem of snowfall has been attacked by the establishment of a large number of snow bins throughout the mountain States, together with tree snow scales in the valleys and ravines. Army scouts, forest rangers, guides, stage drivers, travelers on circuits, and all others of like character have been pressed into service to determine the actual snowfall in the first place and then the extent of drifting and packing in the ravines and gulches, and the depth from time to time in the forests and opens. In fact to be able to tell at any time just how much water is available for irrigation and reservoir purposes and to solve the question of when it may be expected to come down the streams.

All this the Weather Bureau is doing and it is now placing the daily rainfall data before the engineer in monthly form by drainage areas instead of by States as formerly.

The country has been divided into 12 large drainage districts and all the precipitation of each district is published in one table, beginning in July, 1909. Separates are issued for each district covering the climatological data, and special papers discussing climatic and water flow topics. All the separates are then bound together and published as the complete MONTHLY WEATHER REVIEW.

Any person can obtain the separate for any particular district, or the complete REVIEW regularly by making application to the District Editor or the Chief of the Weather Bureau at Washington.

As editor of the Missouri drainage area I wish particularly to solicit items and articles of interest from the members of this Club touching on this great problem of Water Resources and Water Conservation.

I wish to commend to your attention the articles that have already appeared in the REVIEW and which I am sure are worthy of your consideration.

The November number for example contains a paper upon the relation between the precipitation, run-off, and discharge in the Tallahatchie drainage district in Louisiana, another on the hydrography of the South Palouse River, Washington, and another upon important problems in climatology.

Some of the papers in the December number are: The effect of drainage work in Northern Iowa on the flood stages of the rivers, by A. Marston, C. E.; The United States Weather Bureau in the work of the engineer, by J. A. Ockerson, of this Club; The agricultural engineer and the Weather Bureau, by Thos. H. Means; and the Rainfall of the Hetch Hetchy Valley, by Prof. A. G. McAdie, of San Francisco.

Our object is to make this MONTHLY WEATHER REVIEW a great engineering magazine and one that shall be the medium through which climatic matters which touch the use of water in any way shall be treated, and with the hearty cooperation of the engineers, which I am sure we can count on, this ambition will be fully realized.

THE PATHFINDER DAM AND RESERVOIR, WYOMING, WITH REFERENCE TO THE CATCHMENT AREA AND ITS WATER SUPPLY.

By L. V. BRANCH, Engineer in Charge.

The United States Reclamation Service, since its organization in 1902, has constructed, for the purpose of storing flood waters for irrigation use, 3 masonry dams which must be classed with the highest masonry dams ever constructed. These are, namely, the Roosevelt Dam on the Salt River in Arizona, the Shoshone Dam on Shoshone River in northern Wyoming, and the Pathfinder Dam on the North Platte River in central Wyoming. This Pathfinder Dam was the first of the 3 to be completed and it, with the resulting Pathfinder Reservoir, is the subject of this article. The location of this dam and reservoir is shown on fig. 1.

The principal dimensions of the Pathfinder Dam are as follows:

Length on top	432 feet.
Maximum height	218 feet.
Width of dam on top	10 feet.
Width of dam at base	94 feet.
Batter upstream face	15 per cent.
Batter downstream face	25 per cent.
Masonry	60 210 cubic yards.

The first stone was set on August 15, 1906, and the last stone June 5, 1909.

The dam was constructed in a narrow box canyon where the North Platte River cuts through a granite ridge about $2\frac{1}{2}$ miles below the mouth of the Sweetwater River, and 47 miles southwest of Casper, Wyo., the nearest railway station.

The dam is constructed of a hard, coarse-grained granite, quarried near the north end of the dam. Both faces of the dam